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*APPLICATION*  
*FOR*  
*UNITED STATES LETTERS PATENT*

**Title:** Removable Bearing Assemblies

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# REMOVABLE BEARING ASSEMBLIES

This application claims priority to U.S. provisional application 60/184,936 filed February 25, 2000.

## BACKGROUND OF THE INVENTION

### 1. FIELD OF THE INVENTION

The present invention pertains to marine propulsion systems generally, and more specifically to marine propulsion systems utilizing an elongated propeller drive shaft having a housing surrounding the propeller shaft.

### 2. DESCRIPTION OF THE RELATED ART

Modern marine vehicles are most commonly powered by an internal combustion engine mounted within the boat or above the water line adjacent the boat. The mechanical power generated by the engine is transferred through a drive shaft to a water propulsion device such as a propeller. These marine vehicles provide a mode of transportation for traversing bodies of water that may be relatively large and open, such as the larger lakes, rivers and oceans, or relatively smaller, such as streams or creeks, swamps, glades, savannahs and the like.

For boating in open waterways such as lakes, rivers or the oceans, the propeller shaft is typically relatively short, and may extend from the motor and away from the boat hull only a few inches or feet. The spacing between propeller and hull in this type of boat is far smaller than the

overall length of the boat. This short propeller shaft also dictates that the propeller is placed fairly deep into the water, to allow water to circulate past the boat hull and reach the propeller, and to avoid interference between propeller and boat hull during turns and the like. In open waters, where few if any obstacles exist, this arrangement has proven to be very effective and is represented by standard inboard and outboard marine propulsion systems.

Unfortunately, when traversing smaller bodies of water, such as creeks and streams, the rounded boat hulls and deep propeller arrangements used in open waterways are no longer effective or useful. The hull runs deeper than many of these smaller waterways, and the propeller readily becomes tangled in vegetative matter, or, worse, may be destroyed by the obstacles. Particularly for those applications where the water is either shallow or filled with many obstacles, this arrangement is unsatisfactory.

To traverse the shallower bodies of water or those littered with obstacles, it has been proposed to use a flat boat hull and also to extend the propeller drive shaft beyond the boat by a much greater distance. When extended, the propeller can be driven shallowly in the water, free of interference with the boat. When an obstacle is encountered, the boat may pass over and be clear of the obstacle while still being propelled by the motor. Boats that use this type of drive system are sometimes referred to as mud boats, owing to their substantially improved propulsion in shallow waters, swamps, and other muddy waters.

On propulsion systems having an extended drive shaft, it is commonplace to use a housing or casing to surround the drive shaft. Frequently, some type of shroud or structure is also provided to prevent the propeller from directly striking any obstacles, and instead deflects the casing, drive shaft and propeller away from the obstacle. Additional features may be associated with the propeller and casing, such as various reinforcing elements, stiffeners or frameworks. The casing isolates the

rotating propeller shaft from people and objects, thereby preventing the shaft from entangling or harming people or objects. The casing also protects the shaft from impact with hazards, and provides additional structural support to the drive shaft.

5 The use of a long propeller shaft and casing necessitates the provision of bearings or bushings at the ends of the casing, including the end closest to the propeller. While in use, the propeller and adjacent bearing will be submerged for the vast majority of operation. In the prior art, bushings made from brass or the like have heretofore been most commonly used, due to the substantial water exposure. Unfortunately, submerged roller or ball bearings which are not adequately protected from the water rapidly lose grease or other lubricants, thereby leading to early bearing failure. In addition, bushings may be manufactured to add very little extra size to the casing beyond the diameter of the rotating shaft, while bearings tend to be much larger and therefore more prominent. Adjacent the propeller, a prominent bearing translates into significant drag through the water and undesirable mass adjacent the propeller.

10 Because bearings are intrinsically larger than bushings, where they have been used there has been an effort to minimize the package for the bearing, to attempt to offset the bearing dimensions. Unfortunately, it has heretofore been extremely difficult to service those bearings, since some of the features that enabled a part to be serviced in the prior art were the very same features that contributed undesirably to size.

15 Patents exemplary of the prior art include U.S. patents 941,827 to Trouche; 1,953,599 to Grimes; 3,430,603 to Parish; 3,752,111 to Meynier; 4,676,756 to Rodrigue et al; 4,726,796 to Rivette et al; and Des 259,488 to Carter et al, each incorporated herein by reference for their teachings of marine propulsion systems. These patents, several which are associated with commercial products being sold presently, illustrate the use of bushings, particularly adjacent the propeller.

Bushings have for many years been known to present greater friction and wear than bearings, and so to be less desirable, for all but the lowest cost applications where the extra expense of bearings could not be justified and for the special situations where bearings are not acceptable. In the case of the marine vehicles, the added expense of bearings is nominal, and not the motivation for using bushings.

5 Instead, as aforementioned, water exposure and size are primarily responsible for designers resorting to bushings.

Chandler et al, in U.S. patent 2,096,223 incorporated herein by reference, illustrate the use of bearings at both the top and bottom of the propeller shaft. Unfortunately, the Chandler et al patent incorporates the bearings into a much larger and more expensive cast propeller shaft housing. This structure adds significant drag in the water. More importantly though for shallow water application is the additional mass that this structure adds. When an obstacle is encountered, the boat will typically strike it first. Desirably, the boat will be deflected, and, owing to the large area and significant framework typically found in a boat of this nature, the boat will be unharmed or sustain only cosmetic damage. The propeller will next encounter the hazard. The equation from physics that is of interest describes impulse, which is equal to the product of force applied with the time of application, as being proportional to momentum, a product of the mass of the object and the acceleration of that object. The time of impact, within which the propeller must deflect to move around an object, is proportional to the speed of travel through the water. Also, the rate of acceleration is going to also be proportional to the speed of travel and the geometry of both the obstacle and the propeller casing and shroud. Assuming these to be a constant, or, to say it another way, assuming for comparative purposes that the same rate of travel and geometries are used, the time of impact and acceleration may be ignored. The remaining variables are the force that is applied to the propeller hardware, which is then proportional to the mass of that hardware. The greater the

added mass at the end of the shaft, the larger the force that will be applied thereto at a given speed. Consequently, not only is a large and bulky propeller undesirable owing to the increased drag in the water, but also the extra associated mass will lead to much greater impact force, potentially damaging not only the propeller, shaft and casing, but also the mounts and attachments to the boat.

5 The large housing of Chandler et al is therefore undesirable. Furthermore, in the Chandler et al patent there is no discussion of precautions to ensure a water-tight seal, the absence which would lead to early bearing failure.

#### SUMMARY OF THE INVENTION

10 In a first manifestation, the invention is a marine propulsion system having a power source, a rotary drive shaft, a casing surrounding the rotary drive shaft, and a propeller. Ball bearings and bearing races separate the drive shaft from casing. A housing encloses the ball bearings and is removably attached to the casing at a first end and has a first opening adjacent the casing and a second opening. A removable cover is adapted for enclosing the second opening and providing access to the ball bearings. The housing and removable cover serve to isolate the bearings from an  
15 environment exterior of the housing.

In a second manifestation, the invention is a marine propulsion linkage for connecting a propeller to a motive power source. The linkage includes a shaft adapted for rotation about a first axis having a first end and a second end terminating the shaft. A means is provided for coupling the shaft to the propeller adjacent the second end. A means is provided for coupling the shaft to the motive power source adjacent the first end. A casing is generally concentric with the shaft. A framework is attached to the casing and maintains the casing between propeller and motive power source. A bearing housing is removably attached to the casing.

In further manifestations, an additional bearing unit may be provided, and one or more shaft seals may also be provided.

## OBJECTS OF THE INVENTION

A first object of the present invention is to provide bearings in a marine propeller shaft casing. A second object of the invention is to ensure a water-resistant seal that will allow the bearings to be operated for a much longer time than was previously possible. A third object of the invention is to enable the bearings to be replaced with ordinary tools, and not require the use of special machinery or presses, thereby enabling the boat owner to service the bearings if they so choose, or to receive repair assistance in the remote locations where the invention may be used. Another object of the invention is to accommodate standard, complete bearings, including both races and bearings, into the bearing structure, thereby eliminating the need for a large stock of special components, improving the manufacturing yield and reliability of the invention, and furthering the ability for remote servicing. A further object of the invention is to fulfill the foregoing objects in a housing that exhibits a minimum of additional size and mass, to avoid undesirable water drag and mass.

## BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, advantages, and novel features of the present invention can be understood and appreciated by reference to the following detailed description of the invention, taken in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates a preferred embodiment marine propulsion system incorporating a preferred embodiment removable bearing system.

FIG. 2 illustrates a preferred embodiment lower bearing structure from an exploded plan view.

FIG. 3 illustrates the preferred embodiment lower bearing housing from a cross-sectional view taken along line 3' of figure 2.

FIG. 4 illustrates the preferred embodiment lower bearing cover from a cross-sectional view taken along line 4' of figure 2.

FIG. 5 illustrates the preferred embodiment upper bearing structure from an exploded plan view.

FIG. 6 illustrates the preferred embodiment upper bearing housing from a cross-sectional view taken along line 6' of figure 5.

FIG. 7 illustrates the preferred embodiment upper bearing cover from a cross-sectional view taken along line 7' of figure 5.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment marine propulsion system 100 is illustrated in figure 1. A source of motive power 110, which will be known to those in the art to include such devices as internal combustion engines, electric motors and other known motive power sources is operatively connected through appropriate linkage 120 to propeller shaft 130. Shaft 130 passes through casing 140 to propeller 150. A framework 160 is preferably provided, though not essential to the invention, which adds structural integrity to casing 140 while only adding a minimum of mass. At a first end of casing 140 adjacent motive power source 110 is sealed bearing unit 300, and at the opposite end of casing 140 adjacent propeller 150 is sealed bearing unit 200. Sealed bearing units 200, 300 provide ball-bearing support for propeller shaft 130 within casing 140, thereby minimizing friction while improving the life and reliability of marine propulsion system 100.

Sealed bearing unit 200, illustrated by exploded view in figure 2 and cross-section in figures



3 and 4 includes a bearing housing 210 having a threaded nose 212 which is designed to slip between casing 140 and shaft 130, and be threaded into casing 140. The use of threads within nose 212, while not essential to the workings of the invention, is most preferred, since threads are easily produced and are known to readily provide a water-tight and mechanically strong seal, both which are preferred in the present invention. An inner bore 213 is provided which is preferably slightly greater than the diameter of shaft 130, so as to provide adequate clearance therebetween. Too large an inside diameter for bore 213 will weaken threaded nose 212 undesirably, while too small and shaft clearance as well as the ability to remove bearings 260 - 264 will be adversely affected, as will be described herein below. Inner bore 213 leads to bearing compartment 215, which has a much larger inside diameter.

Most preferably, bearing compartment 215 will be sufficiently large that bearings 260-264 may contain not only a bearing, but also be provided complete with inner and outer bearing races. This is most preferred, since the construction of bearings is a precise art where small deviations are known to have adverse affects upon the performance of the bearings. Furthermore, special materials and treatments are required, the processes which are highly refined in the production of reliable bearings. These processes are used in high volume in the production of bearings, thereby adding little to the total cost of the bearing. However, to incorporate this level of precision and processing into the present bearing unit 200 would add undesirably to the cost, and, absent the full technology used in the bearing industry, would also lead undesirably to lower production yields and greater failures during use.

One additional advantage comes from the use of complete bearing structures. In use, when a complete bearing structure fails, the failure often times destroys the bearing but less frequently damages shaft 130 or bearing compartment 215. Consequently, only bearings 260-264 will need

replacement, and, as long as relatively common bearings are used for bearings 260-264, these bearings may be obtained from bearing supply sources, hardware dealers and the like which are located in most small towns throughout the world. The exact type of bearing used is not critical to the invention, and different types including ball and roller bearings are contemplated herein. Nevertheless, while less preferred, it is contemplated herein to use bearings such as needle bearings and the like which do not include outer races, and which would therefore consume less space, and instead use bearing compartment 215 as the outer race. Using bearings without a race provides a size advantage, since, without bearing races, bearing housing 210 may be made with a much smaller outside diameter more closely resembling or even the same as casing 140.

Three bearings 260-264 are most preferred, owing to the affects of bending within shaft 130 during operation, particularly when an obstacle is encountered. When shaft 130 is flexed out of being exactly coaxial with bearing unit 200, a force is applied radially in a first direction against bearing 264 and radially in an opposite direction against bearing 260, while bearing 262 will operate essentially in balance and serve as a point of pivot for shaft 130. The benefit is the lack of twisting forces applied to a single bearing, thereby enhancing the overall life of the bearing structure. Furthermore, the total load supported by the three bearings 260, 264 is, of course, distributed across all three bearings. While it may be possible to manufacture a bearing structure having only one or two bearings therein, it is less preferred.

Once bearings 260-264 inserted within bearing compartment 215, a small retaining ring 250, which may be a split ring, e-clip or the like, is inserted within groove 217. Next, shaft seals 230, 235 are inserted within cover 220. These seals are elastomeric on an inner diameter, which will engage with shaft 130, and will most preferably include grease or the like, not only for lubrication, but also for the water repellent nature of grease and oil. Through the combination of grease and shaft seals

230, 235, no water should penetrate into bearing compartment 215. Threads 226 will engage with threads 216, and may solely be used as the final seal against water intrusion into compartment 215. However, it is also contemplated to provide an elastomeric seal 240, which may be a washer or o-ring, between cover 220 and bearing housing 210. A similar elastomeric seal is contemplated, but not preferred, for use in association with shoulder 214 and casing 140.

Bearing housing 210 and cover 220 may be machined from carbon steel, stainless-steel or other suitable material. The exact material is not critical to the performance of the invention, provided there is sufficient strength to withstand the forces of impact that may occur during use, as well as the forces which occur during general use. The geometries illustrated are all cylindrical, which allows bearing housing 210 and cover 220 to each be manufactured through low-cost turning and drilling procedures.

In use, shaft 130 passes through the center of bearing housing 210 into the center of ball bearings 260-264, where the drive shaft is radially supported. In the event bearings 260-264 should seize and rotate relative to housing 210, housing 210 may be damaged. Nevertheless, should this occur housing 210 may then be removed from casing 140 and replaced. While a local source may not be available, the overnight shipping charges for bearing housing 210 are substantially lower than for a full casing 140. Similarly, in the event casing 140 should be damaged and unuseable, only casing 140 must be replaced and not bearing unit 200. Likewise, should shaft 130 be the only damaged component, then only shaft 130 will need replaced.

In the event one or more bearings 260-264 fail without damaging bearing housing 210, bearing unit 210 may be removed from casing 140 and shaft 130, and then cover 220, seals 230, 235 and retaining ring 250 are removed. Finally, a punch, screw-driver or the like may be used to press axially against the side of bearing 264 most adjacent shoulder 214, to press bearings 260-264 out of

bearing housing 210. The ability to remove bearing housing 210 from casing 140 allows better access to bearings 260-264, as long as inside bore 213 is slightly greater in diameter than the inside diameter of bearings 260-264. Other techniques may be provided to assist with the removal of bearings, such as the provision of one or more small grooves extending axially within bore 213, though the simplicity of the present inner bore 213 is preferred herein.

While bearing housing 210 is most preferably removable from casing 140, it is conceivable that bearing housing 210 could be manufactured to be an integral part thereof. In this case, access to bearings 260-264 may be somewhat more difficult. Regardless of whether removable or integral, bearing housing 210 will still most preferably present an outer surface which most closely resembles the outer surface of casing 140. Shoulder 214 assists in this regard by presenting a preferable steep angle, which enables tight coupling to casing 140, thereby reducing surface irregularities that would otherwise cause undesired turbulence. When the turbulence becomes too great, or when bearing housing 210 has too great a protrusion from casing 140, water will spray up into the air when propeller 150 is operated in shallow water. This is very undesirable.

Figures 5 - 7 illustrate a preferred top bearing unit 300, which resembles bottom unit 200 in most features, which will not be repeated herein. The corresponding drawing elements are identified by the second and third digits of the element numbers between the two units. However, a few features are somewhat different. As can be seen, threads 313 form a female connection to casing 140, which will be exterior threaded. This arrangement assists with draining water from the bearing unit and threads, since casing 140 will be lower than bearing unit 300, and will therefore drain water from threads 313. With this arrangement, a stop 318 may optionally be provided past which casing 140 may not pass, but through which shaft 130 will pass.

Additionally, only a single bearing 360 is illustrated. Once again, the exact number and

dimensions of bearings is not critical to the invention. However, since bearing unit 310 is not submerged, and therefore the exterior diameter of housing 310 is less important, a larger single bearing 360 may be used. The attendant advantages described herein above of using three separate bearings may not be attained, but may be compensated for owing to the larger size of bearing 360.

While the foregoing details what is felt to be the preferred embodiment of the invention, no material limitations to the scope of the claimed invention are intended. Further, features and design alternatives that would be obvious to one of ordinary skill in the art are considered to be incorporated herein. For example, while a strong and corrosion resistant material such as stainless, coated or otherwise treated steel is described as preferable for manufacturing bearing housings 210, 310 and covers 220, 320, materials such as ABS plastic and the like are also contemplated. These and other materials might also be produced using different manufacturing techniques as well, such as molding or casting. The scope of the invention is not limited to the particular preferred embodiments described herein, and instead is set forth and particularly described in the claims hereinbelow.